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Signed this May 31, 2002

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This is to certify that the annexed is a true copy of the following application as filed this Office.

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[List of the contents]

[Document] Specification 1

[Document] Drawings 1

[Document] Abstract 1

[Assigned Number of Applicant to the Attorneys] 9005894

[Proof] necessary

[Document Name] Specification

[Title of the invention] Solar Cell Module

[Scope of Claim for Patent]

[Claim 1] A solar cell module comprises a solar cell element sealed with sealing resin between a front surface glass member and a rear surface member , wherein

the solar cell element has a semiconductor junction positioned on an opposite side to the front surface glass member.

[Claim 2] The solar cell module according to claim 1,

wherein the solar cell element is so structured that light enters from a side opposite of the junction.

[Claim 3] The solar cell module according to claim 1,

wherein the rear surface member is formed of transparent material.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

This invention relates to a solar cell module, particularly to a two-side incidence type solar cell module provided with transparent front and rear surface members capable of entering light from both front and rear surfaces.

[0002]

[Prior Art]

Because solar light is unexhausted energy, a solar cell device for directly converting light energy into electrical energy has been developed as an energy source to substitute for environmentally harmful fossil fuel such as petroleum and coal. A plurality of solar cell elements is electrically connected

in series or in parallel with each other to form a solar cell module and increase their output. The solar cell module can be used as a practical energy source.

[0003]

A conventional solar cell module which generates power on one side surface is so structured that a plurality of solar cell elements 110 between a front surface glass 100 and a rear surface member 101 are sealed with transparent and insulative resin 102 such as EVA (ethylene vinyl acetate). The rear surface member 101 is a lamination film with a metal foil such as an aluminum (Al) foil or the like sandwiched with plastic films so that water entrance from a rear surface can be prevented.

[0004]

The solar cell element 110 contains single crystalline silicon, polycrystalline silicon, or the like, and the solar cell elements 110 are connected in series by connection member 111 of a metal thin plate such as a copper foil plate or the like. The solar cell element 110, as shown in Fig. 4, is so structured that n-type impurities are diffused on a p-type single crystalline silicon substrate 110a to form an n-type semiconductor layer 110b so that a semiconductor junction is formed. The rear surface electrode 110d of aluminum (Al) is formed on a rear surface side of the substrate 110a. The aluminum of the rear surface electrode 110d is diffused and a p+-type diffusion layer 110c is formed on the rear surface side of the substrate 110a. A comb-shaped electrode 110e of silver (Ag) is formed on a front surface side of the substrate and a silicon dioxide (SiO_2) layer as a reflection preventing layer 110f is formed.

[0005]

A conventional solar cell module has a structure with a semiconductor junction arranged on a light incidence side of a front surface glass on as shown in Fig. 4 so that many carriers are generated on the light incidence side and a strong electric field on the junction separates the carriers.

[0006]

A solar cell element capable of entering light from both front and rear surfaces with a structure that the electrode provided on the rear surface side not only on the front surface side is formed of transparent material has been proposed in order to efficiently utilize light.

[0007]

[Problems to be resolved by the Invention]

In the meantime, a solar cell module should be weather proof in order to withstand long-term use outside. When a lamination film in which the metal foil is sandwiched with plastic films is used as the rear surface member 101, water entrance from outside is suppressed and high power generation performance can be obtained for a long period of time.

[0008]

However, when a transparent resin film is used as the rear surface member, water is likely to enter as compared with the lamination film with the metal foil sandwiched with plastic films, thereby requiring other measures against water. Although a film of a small water vapor transmission rate has been proposed as a transparent resin film, improvement is still required.

[0009]

This invention was made to solve the existing problems and provide a solar cell module capable of improving reliability by improving moisture proofness.

[0010]

[Means of Solving the Problems]

First of all, inventors of the present invention made a moisture proof test (JIS C8917) in order to diagnose degradation of power generation performance by water entrance. In the test, the inventors tested a solar cell module shown in Fig. 3 using a lamination film of an aluminum foil sandwiched with polyvinyl fluoride films as a rear surface member 101, and a solar cell module only using a PVF film as the rear surface member 101. The solar cell elements arranged in the solar cell modules comprise a semiconductor junction on a side of a front surface glass to which light enters. In general, a module is put in a thermostatic bath of 85℃, 93% RH for approximately 1000 hours and a solar cell characteristic is examined and an acceptable value of output is higher than 95%. In this test, the modules are put in the thermostatic bath for 1000 hours. As a result, the output change rate is 99.0 % when the rear surface member is a lamination film, and the rate is 92.0 % when the PVF film is used. A quantity of sodium in 1g of the resin for sealing the solar cells of the solar cell module using the lamination film is 0.3μg/g, and that of the solar cell module using only the PVF film is 3μg/g. The quantity of sodium relates to changes in the rate of output, and as the quantity of sodium in the resin increases, the power generation performance degrades.

[0011]

An increase of sodium quantity seems to result from the water entered in the module. The water enters from an outer periphery of the solar cell module

when the rear surface member is the lamination film. On the other hand, when the rear surface member is the resin film, water enters not only from the outer periphery of the solar cell module but also from the resin film. As a result, when the rear surface member is the resin film, the water entering in the module increases.

[0012]

When the water enters in the solar cell module, the sodium ion deposited from the front surface glass migrates inside the resin containing the water and reaches to the surface of the solar cell element. Then, trap level is formed in the solar cell module and causes carrier loss. As a result, the power generation performance of the solar cell element degrades. Therefore, it is assumed that the resin film on the rear surface causes degradation of power generation performance. The cause of this phenomenon is not clearly understood so far, but is supposed that the sodium (Na) does not directly join with silicon (Si), and affects through oxygen. Therefore, it is expected that the sodium works with an impurity diffusion layer (a dope layer) having a natural oxide layer on its surface or slightly remaining oxygen in a substrate. When level is formed on a dope layer, a build-in electric field is weakened by reduction of carriers, and re-joining increases at an interface thereby degrading characteristics.

[0013]

This invention was made to improve reliability by not having alkaline composition such as the sodium deposited from the front surface glass affect the semiconductor junction of a solar cell element.

[0014]

A solar cell module of the present invention was made in view of those mentioned above. The solar cell module comprises a solar cell element sealed with sealing resin between a front surface side glass member and a rear surface member. The solar cell element comprises a semiconductor junction positioned on an opposite side to the front surface glass member.

[0015]

The solar cell element is so structured that light enters from a side opposite of the junction.

[0016]

The rear surface member is formed of transparent material.

[0017]

With the above structure, the alkaline composition such as the sodium ions are shielded by a thick bulk semiconductor, and effects to a junction part which is important in forming an electric filed can be substantially eliminated. Therefore, degradation of power generation performance of the solar cell element can be prevented.

[0018]

[Embodiment]

Explanation is made on the embodiment of this invention by referring to the drawings. Fig. 1 is a schematic cross sectional view of a solar cell module of the first embodiment of this invention.

[0019]

The solar cell module in the embodiment generates power at both front and rear surfaces, and has a structure that, as shown in Fig. 1, a plurality of solar cell elements 3 is sealed with transparent and insulative resin 4 such

as EVA (ethylene vinyl acetate) between a front surface glass 1 and a rear surface member 2. The rear surface member 2 is a transparent plastic film of PVF or the like so that light can enter from the rear surface. In Fig. 1, a single unit of the solar cell element 3 is shown. The solar cell elements are connected with each other in series or in parallel by a connection lead such as a copper foil.

[0020]

The solar cell element 3 used in the solar cell module of this invention has a semiconductor junction formed by which n-type impurity is diffused on a p-type single crystalline silicon substrate 31 and an n-type semiconductor layer 32 is formed. A comb-shaped electrode 33 of Ag is provided on the n-type semiconductor layer 32 and a reflection preventing layer 34 of a silicon dioxide (SiO_2) layer is formed thereon.

[0021]

The solar cell element 3 is arranged in the solar cell module so that the semiconductor junction of the solar cell element 3 is positioned on an opposite side of the front surface glass substrate 1. Therefore, it is required that the solar cell element 3 can enter light from an opposite surface to the surface for forming junction in the conventional solar cell element. Thus, after forming a p+-type diffusion layer 35 positioned on a side of the glass substrate 1 by aluminum diffusion, the Al is eliminated or a p+-type amorphous semiconductor layer is formed on the substrate 31 in order to achieve light entrance. The comb-shaped electrode 36 of Ag is formed on the p-type semiconductor layer 35, and a reflection preventing layer 37 of a silicon dioxide (SiO_2) layer is formed.

[0022]

The solar cell elements are sandwiched with an EVA resin sheet between the front surface glass 1 and the rear surface member 2 so as to locate semiconductor junction of the solar cell element 3 on an opposite side of the front surface glass 1, and is heated under a reduced pressure so that the module is integrally formed. As shown in Fig. 1, the plurality of the solar cell elements are sealed with the EVA resin between the front surface glass 1 and the rear surface member 2, where the semiconductor junction is positioned on an opposite side to the front surface glass 1.

[0023]

As described above when the semiconductor junction is apart from the front surface glass 1, the alkaline component such as the sodium ions are shielded by a thick bulk semiconductor, and effects to a junction part which is important in forming an electric filed can be substantially eliminated. Therefore, degradation of power generation performance of the solar cell element 3 can be prevented. As a result, a highly reliable solar cell module capable of withstanding long-term use outside can be provided.

[0024]

The solar cell module of the above-mentioned structure according to this invention and a conventional solar cell module are prepared, and moisture proof test is conducted. This test is for examining characteristics of the solar cells before and after retained in a thermostatic bath of 85℃, 93% RH for 1000 hours. An acceptable value of an output is not lower than 95%. The results are shown in table 1.

[0025]

The sample of the invention includes a transparent plastic film of PVF (polyvinyl fluoride) so as to enter light from the rear surface. The conventional example includes a lamination film of a metal (Al) foil sandwiched with plastic films of PVF as the rear surface member. The conventional example and the sample of the invention have the same structure except that the material of the rear surface member is different, and the semiconductor junction is positioned on a side of the glass substrate or on an opposite side of the glass substrate.

[0026]

[Table 1]

	Pmax	Voc	Isc	F.F.
Module of this invention (p-type substrate)	99.1%	99.9%	100.0%	99.2%
Module of the conventional example (p-type substrate)	95.8%	99.4%	100.0%	96.3%

[0027]

Each of the values in the table is a rate of change from initial characteristics. As indicated in the table 1, degradation of the characteristics is suppressed in spite of the rear surface member of a plastic film which is subject to water entrance in the module with semiconductor junction positioned on the opposite side of the front surface glass 1.

[0028]

Explanation on the second embodiment of the invention is made by referring to Fig. 2. As shown in Fig. 2, this embodiment uses the solar cell element 5 capable of entering light from both front and rear surfaces and having a structure (an HIT structure) which a substantially intrinsic amorphous silicon is sandwiched between the single crystalline silicon substrate and the

amorphous silicon layer so that defects on the interface are reduced and characteristics of the hetero junction interface are improved.

[0029]

As shown in Fig. 2, the solar cell element 1 includes an n-type single crystalline silicon substrate 51, an intrinsic amorphous silicon layer 52, and a p-type amorphous silicon layer 53 formed in this order. A transparent electrode 54 on a light receiving side formed of ITO or the like is formed on an entire surface of the p-type amorphous silicon layer 53, and a comb-shaped collector 55 of silver (Ag) or the like is formed on the transparent electrode 54 on a light receiving side. An opposite surface of the substrate 51 has a BSF (Back Surface Field) structure which introduces an internal electric field on the rear surface of the substrate; a high dope n-type amorphous silicon layer 57 is formed with an intrinsic amorphous silicon layer 56 interposed on an opposite surface side of the substrate 51. A transparent electrode 58, which is formed of ITO or the like, on a rear surface side is formed on an entire surface of the high dope n-type amorphous silicon layer 57, and a comb-shaped collector 59 of silver (Ag) or the like is formed thereon. The rear surface also has a BSF structure which the intrinsic amorphous silicon layer is sandwiched between the crystalline silicon substrate and the high dope amorphous silicon layer in order to reduce defects on the interface and improve characteristics of the hetero junction interface.

[0030]

The solar cell elements 5 are connected in series with connection members (not shown). The solar cell elements 5 are arranged so as to position semiconductor junction on an opposite side to the front surface glass 1; that

is a comb-shaped collector 59, which is usually positioned on a side facing to the rear surface, is positioned on the side facing to the glass substrate 1, and a p-type amorphous silicon layer 53 for forming a semiconductor junction is positioned on the side facing to the rear surface film 2.

[0031]

The solar cell element 5 with the semiconductor junction positioned on the opposite side to the glass substrate 1 is sealed between the front surface glass 1 and the transparent rear surface film 2 of PVF or the like by using EVA (ethylene vinyl acetate) resin 4.

[0032]

As described above when the semiconductor junction is apart from the front surface glass 1, the alkaline component is shielded by a thick bulk semiconductor, and effects to a junction part which is important in forming an electric filed can be substantially eliminated. Therefore, degradation of power generation performance of the solar cell element 5 can be prevented. As a result, a highly reliable solar cell module capable of withstanding long-term use outside can be provided.

[0033]

The solar cell module of the structure according to this invention and a conventional solar cell module are prepared, and moisture proof test is conducted. This test is for examining characteristics of the solar cells before and after retained in a thermostatic bath of 85℃, 93% RH for 1000 hours. An acceptable value of an output is not lower than 95%. The results are shown in table 2.

[0034]

The sample of the invention uses a transparent plastic film of PVF (polyvinyl fluoride) as a rear surface member 2 so as to enter light from the rear surface. The conventional example includes a lamination film of a metal (Al) foil as the rear surface member sandwiched with plastic films of PVF. The conventional example and the sample of the invention have the same structure except that the material of the rear surface member is different, and the semiconductor junction is positioned on a side of the glass substrate or on an opposite side of the glass substrate.

[0035]

[Table 2]

	Pmax	Voc	Isc	F.F.
Module of the invention (HIT cell)	99.5%	100.0%	99.9%	99.6%
Module of conventional example (HIT cell)	95.9%	99.5%	99.9%	96.5%

[0036]

Each of the values in the table is a rate of change from initial characteristics. As indicated in the table 2, degradation of the characteristics is suppressed in spite of the rear surface member of a plastic film which is subject to water entrance in the module with semiconductor junction positioned on the opposite side of the front surface glass 1.

[0037]

In the above description, a heat diffusion type single crystalline silicon solar cell element, and a solar cell element of an HIT structure are used. In addition, a crystalline solar cell element using other types of single crystalline silicon and polycrystalline silicon and an amorphous solar cell element are also applicable for a solar cell module.

[0038]

[Effects of the Invention]

This invention can provide a highly reliable solar cell module capable of withstanding long-term use outside by suppressing sodium ions deposited from a front surface glass from reaching to a solar cell element, and retarding degradation of power generation performance of the solar cell element.

[Brief Explanation of the Drawings]

[Fig. 1]

Fig. 1 is a schematic cross sectional view illustrating a solar cell module of an embodiment according to this invention;

[Fig. 2]

Fig. 2 is a schematic cross sectional view illustrating a solar cell module of another embodiment according to this invention;

[Fig. 3]

Fig. 3 is a schematic cross sectional view illustrating a conventional solar cell module;

[Fig. 4]

Fig. 4 is a schematic cross sectional view illustrating the conventional solar cell module.

[Explanation of reference number]

1 front surface glass

2 rear surface member

3 solar cell element

[Document name] Abstract

[Abstract]

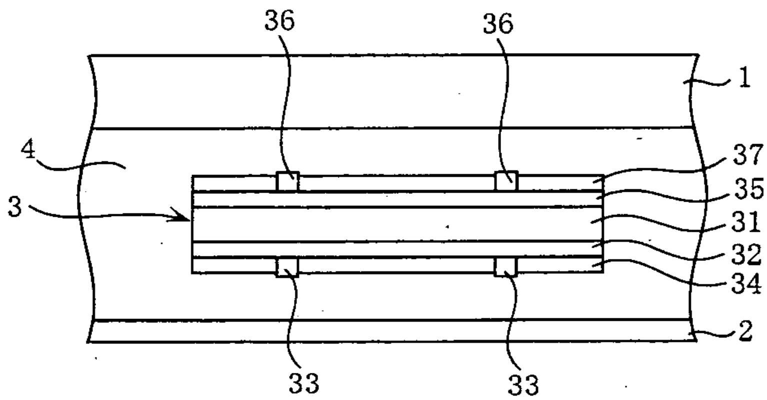
[PROBLEM TO BE SOLVED] To provide a solar cell module whose reliability is enhanced by improving its moisture proofness.

[SOLUTION] In the solar cell module, a solar cell element 3 is sealed with an EVA resin 4 between a front surface glass 1 and a rear transparent film 2. The solar cell element 3 is arranged, in such a way that the semiconductor junction of the solar cell element 3 is positioned on the opposite side to the surface glass 1.

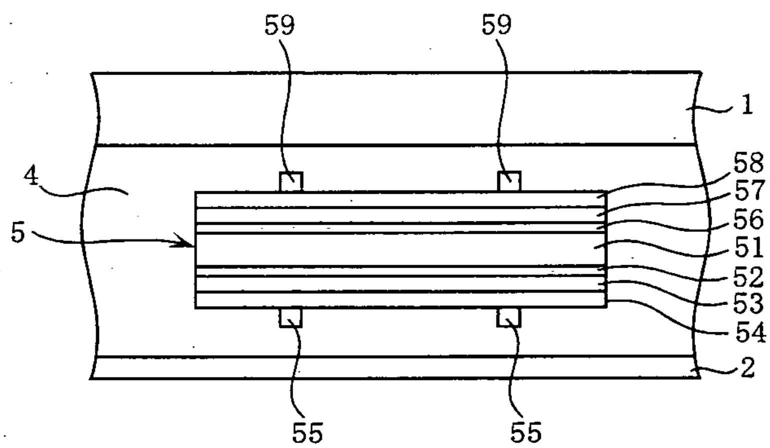
[Selected drawing] Fig.1

【Document Name】 Drawing

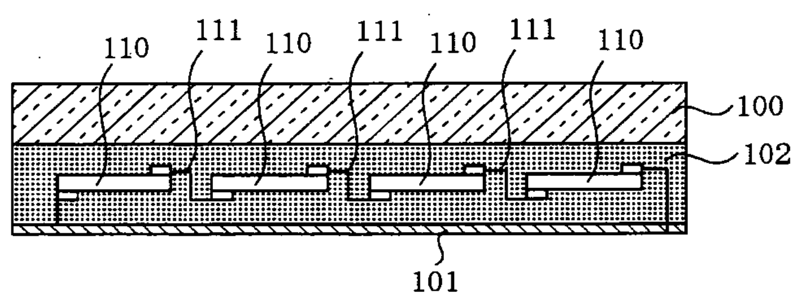
【Fig. 1】



【Fig. 2】



【Fig. 3】



【Fig. 4】